Gail Purvis

In the Semiconductor 2003 meeting in Edinburgh in June, the prime message for the compound sector from both Bookham's Andy Carter and Intense Photonics' John Marsh was 'integration.' From Prof Gabriel Aeppli of University College London, the nano technology message was that μ-scale electronics is already a working science; revolutionised by scan probe microscopy and e-beam litho, it cannot be distinguished from modern materials science; but the trick will be in 'learning to control it.'

Integration and control

Talking on hybrid and monolithic integration technologies for metro and long haul optical systems, Bookham's VP R&D Andy Carter laid the scene with the company's history since 1988, which has developed into the core compound skills of GaAs and InP modulator technologies, InP tunable laser technology and ASOC silicon integration.

Pointing out that compound was a long way behind the silicon industry, Carter noted however, that on-chip integration allowed mass manufacture, down-sizing, power and cost and co-packaging. The integration imperative was emerging, driven by equipment manufacturers wanting "solution level" products, rather than discrete "components."

However there were varying levels of integration, he said. Co-packaging often will not deliver the required cost reduction. For hybrid products yield must be high and cost low. Monolithics must deliver performance at least equivalent to discrete solutions, with the benefits of reduced size and cost.

Bookham's enthusiasm for manufacturing is well matched by its latest acquisition Cierra Photonics' AED

At Bookham, GaAs gives high performance integrated modulation; InP offers monolithic tunable sources and metro, long-haul modulators and ASOC provides platforms for smart passives and hybrids.

Bookham is well into pick & place, laser welding and automation for high volume assembly. If anyone doubted that apart from portfolio acquisitions, Bookham's obsession is manufacture, it's latest acquisition of Cierra Photonics is proof of both puddings.

Aware that the shrinking market for discrete components is yielding to a potentially expanding market for integrated subsystems from companies that have large portfolios of active and passive technologies to hand, Bookham's acquisitions from Marconi was for components; from Nortel Networks transmitters, receivers, and amplifiers. Now Cierra provides the passives.

Its thin-film technology addresses the requirements for multiplexer, demultiplexer devices handling 4, 8, or 16 wavelengths. This is used for the increasingly popular Coarse Wavelength Division Multiplexing, complimenting Bookham's existing Arrayed Waveguide Grating for 20 or more wavelengths used in DWDM.

But Cierra is equally reputed for its manufacturing technology, self styled Advanced Energetic Deposition. In March this year it announced significant enhancements in fibre optic component production efficiency through greater capacity and lower costs offered with its third version of the AED process, specialised for wafer-scale deposition of extremely well-controlled films.

Bookhamwants new markets, but it's equally entranced by better manufacture.

High power tunable lasers as a monolithic solution, with high power DFB and DBR, allows multiple functions, reduces costs, simplifies fibre management and offers new capability. A common platform gives reduced cost, volume sharing, rapid product introduction and leverage proven reliability; scalability through 6"GaAs and 3"InP gives high volume, with automated assembly allows flexibility in yield.

QWI integration

For Intense Photonics, its strategic officer Professor John Marsh also talked on the potential of optical communication networks through integration. With a shorter history only dating back to 2000 and a manufacturing facility acquired from a former silicon mask supplier in 2001, Intense is also devoted to developing monolithic integration of GaAs and InP. But its approach has been to use Quantum Well Intermixing (QWI) to integrate the multiple optical functions such as laser, modulators and amplifier onto the one chip.

For Intense Photonics the benefits of integration depend on the context of enhanced capability, manufacturability and new functionality, but it too carries the ubiquitous message of reduced cost, smaller footprint and less power.

QWI for instance offers multiple bandgaps in AlGaInAs/InP with varying wavelength which effectively gives four lasers on a single chip.

The QWI process is re-growth free, scalable, high yield and a single stage, but more intriguing are numbers in the power budget (Figure 1) where the discrete contrasted to the integrated, shows significant variation advantages.

Intense Photonics' founding CEO David Lockwood (left) and Professor John Marsh turned chief strategy officer holding a metro networking system laser.

Do roadmaps lead or follow?

There were some oblique considerations for the compound sector too, posed by silicon-biased speakers such as Martin McCallum, manager of advanced lithography development at Nikon Precision Europe. Joking whisky's potential, he discussed water immersion lithography (collaborative work with resist experts, Tokyo Ohka Kogyo) and electron projection lithography (collaborative work with IBM, Fishkill) as the first Nikon EPL tool was due to ship out to the Selete consortium.

McCallum raised the intriguing issue that despite their promise, immersion and EPL do not fit neatly into the present silicon roadmap. Was the roadmap, he queried, leading by setting targets to which industry re-calibrates every few years? Or was the map simply following developments?

"Nikon believes that the roadmap has a role in industry," he answered, adding, "We will develop what we feel is the most appropriate technology for a market. It is novel R&D that drives the industry, not what the roadmap asks for."

Risks high or low exist in all forms of post 193µ lithography he said. Currently no clear technology is the 'winner" "Today we may not even have considered the technology we will use at 0.32µ!"

Call for nano control

Professor Aeppli pondered the fact that semiconductor and magnetic storage technology will improve rapidly, but the cost of each generation of fabrication will grow at least as rapidly. "Can we really go to atomic scale for future solid state electronics? Can we get devices to work together with µ features?" Among problems he highlighted were cheap and reproducible fabrication, interaction between components at short distances, fault tolerance of materials disorder and quantum/thermal disorders. But his philosophy is problems offer engineering opportunities – including quantum computing; defects as functional devices; work on fault tolerant systems and (with barely suppressed joy) a move away from the gate-based , linear architectures of Von Neumann-Turing. For nanotechnology opportunities, interdisciplinary integration is going to be tougher than compound and silicon, and the future will also need serious thought on manufacture and systems issues.

Figure 1: Power Budget — **Courtesy of Intense Photonics**

Discrete approach

Laser	Coupling losses	Amplifier	Coupling losses	Modulator	Coupling loses	Power in fibre
Output power 0dBm	out 2dB in 1dB Total 3dBm	+10dB	out 2dB in 0dB Total 2dBm	Insertion loss -5dB	out 1dB in 2dB Total 3dBm	-3dBm

Integrated approach

Laser	Coupling losses	Amplifier	Coupling losses	Modulator	Coupling loses	Power in fibre
Output power 0dBm	out 0dB in 0dB Total 0dBm	+10dB	out 0dB in 0dB Total 0dBm	Insertion loss -8dB	out 0dB in 0dB Total 0dBm	+2dBm